Using NASA Data and Models to Improve Heat Watch/Warning Systems for Decision Support

NASA Public Health Review, 2012

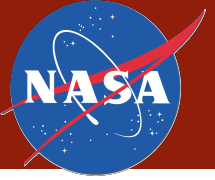
Dr. Daniel Johnson, Ph.D.
Chair
Department of Geography (IUPUI)
Director
Institute for Research on Social Issues

Austin Stanforth, MS
Graduate Research Assistant
Dept of Geography (IUPUI)

September 19, 2012

INDIANA UNIVERSITY

CENTERS FOR DISEASE CONTROL AND PREVENTION



INDIANA UNIVERSITY

Model Development

UPDATE ON ACTIVITIES FOR PAST YEAR (YEAR 3, 2011-2012)

Summer of 2012 notable

- Multiple Extreme Heat Alerts in each of our cities
- Hottest summer across much of U.S.
- Earlier events lacked significant humidity

Great PR

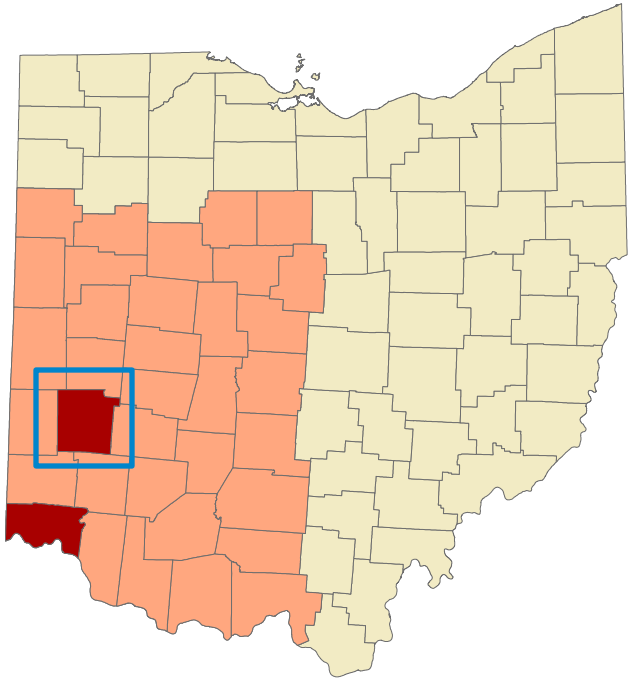
- This helps set the stage for implementation and developing further interest.
- Identified areas our cities need help with

Current Heat Health Alert Systems: Overview of Deficiencies

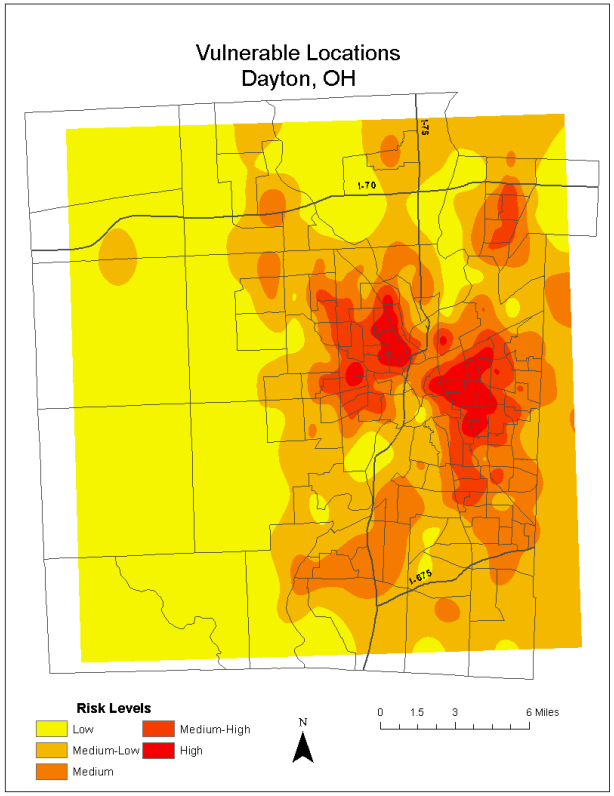
- Much of the deficiency has to do with spatial specificity. Where are the vulnerable? Where are the "hot spots"? Both thermal and health-related.
- 'Current protocols for issuing heat alerts using synoptic weather models are very good.'
  - Current research is beginning to reconsider this statement (cf: Matte, 2010)

Spatial Specificity in Heat-Related Warnings: The Past and the Future

Current Systems



Our Systems



- *Allow for 'polygon' alert system*
- *Placement of medic and cooling centers*

The “Discontinuous” UHI

The Micro-UHI Effect (Dayton)

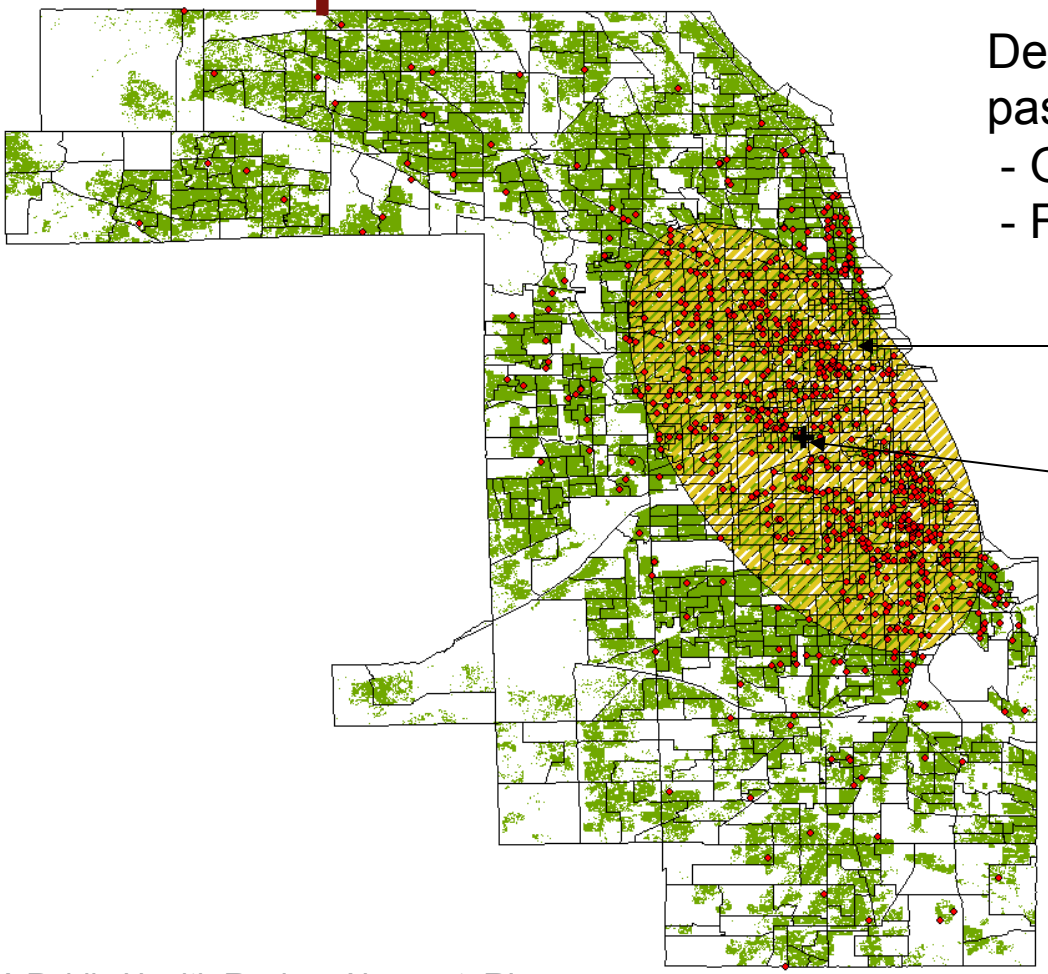
Important Data Considerations

- Use census socioeconomic data at the census tract/block group level
  - -Minority populations, lower income, lower educational attainment, and aged population
  - -Extract residential land use for population density calculation

Population Density Calculated by ***Area*** of Residential Land Use

Future application may use EMS 'commute' variables

Important Data Considerations



Death certificates collected for past analog events

- Geocode locations of mortality
- Further explore spatial distribution

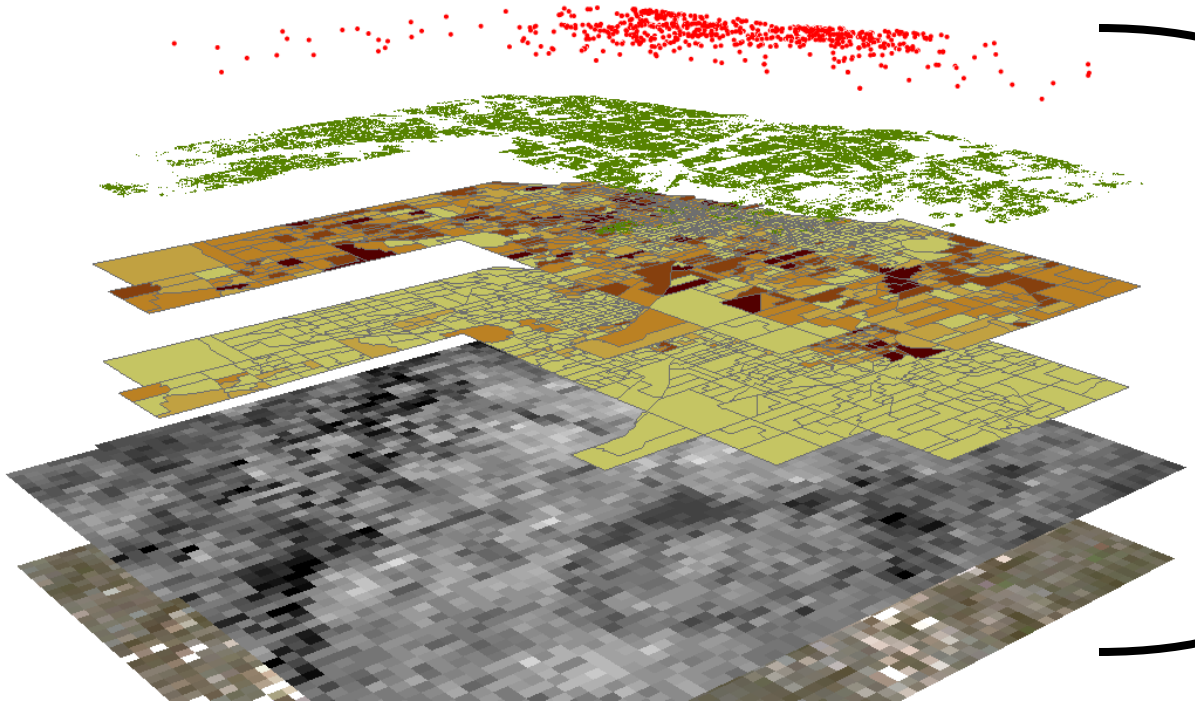
1 SDE for Mortality

Mean Center of Mortality

Mortalities have been randomly offset by 50-100 meters.

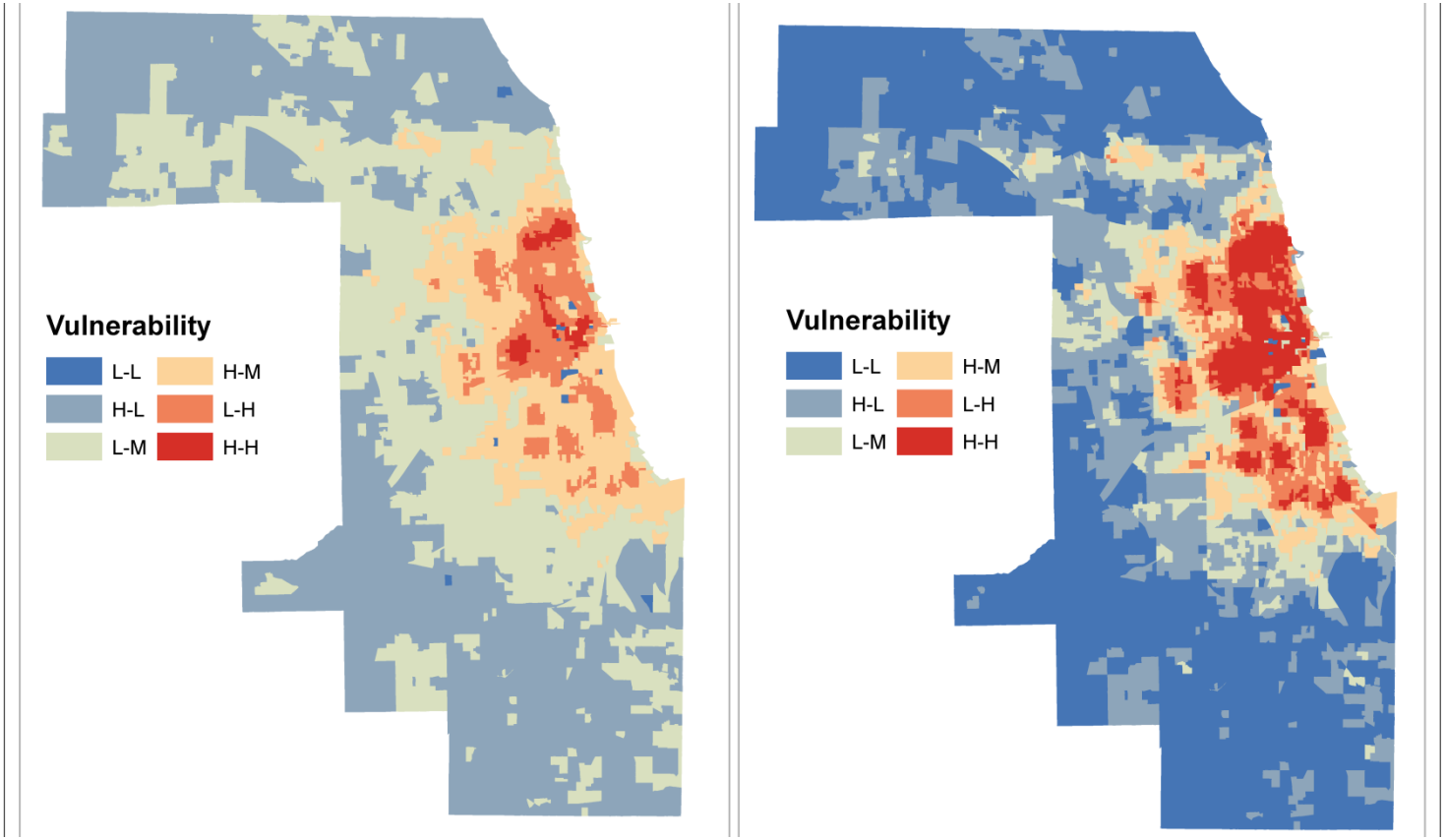
Future – 911 call

Developing the Extreme Heat Vulnerability Index (EHVI)



Risk to Extreme Heat is Hyper-dimensional

Extreme Heat Vulnerability Index

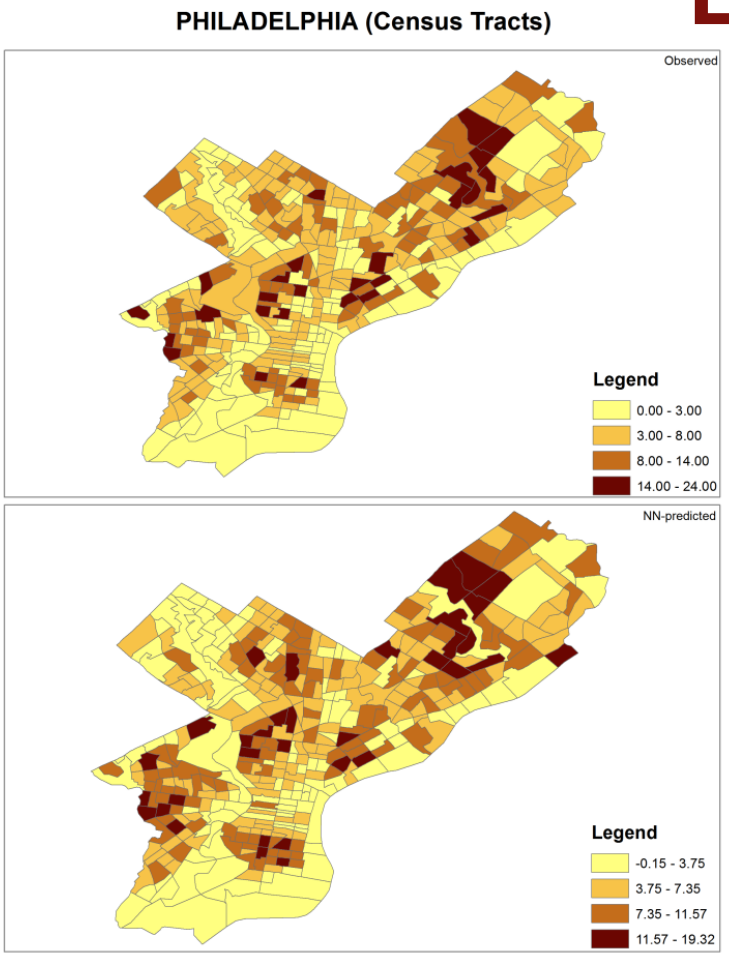


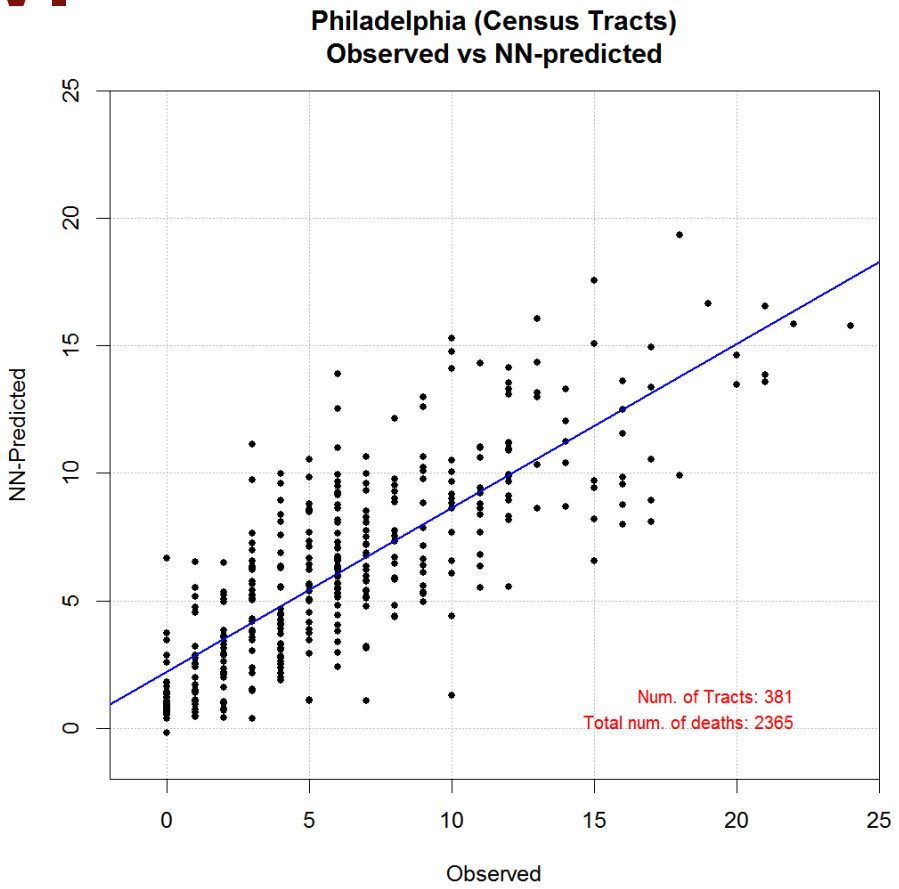
EHVI Tested with Neural Networks

- All outputs from 12-3-1 Multilayer Perceptron (MLP)†
- Different architectures need to be tried.
  - With different number of hidden nodes.
  - With different input variables.
  - Combination of both?
- Different networks need to be tried.
  - Self Organizing Maps (SOM)
  - This can also improve our EHVI

† Modern Applied Statistics with S (2002) by W. N. Venables and B. D. Ripley

EHVI


PHILADELPHIA (Census Tracts)
Observed
Legend
0.00 - 3.00
3.00 - 8.00
8.00 - 14.00
14.00 - 24.00
NN-predicted
Legend
-0.15 - 3.75
3.75 - 7.35
7.35 - 11.57
11.57 - 19.32


Philadelphia (Census Tracts)
Observed vs NN-predicted
NN-Predicted
Observed
0
5
10
15
20
25
Num. of Tracts: 381
Total num. of deaths: 2365

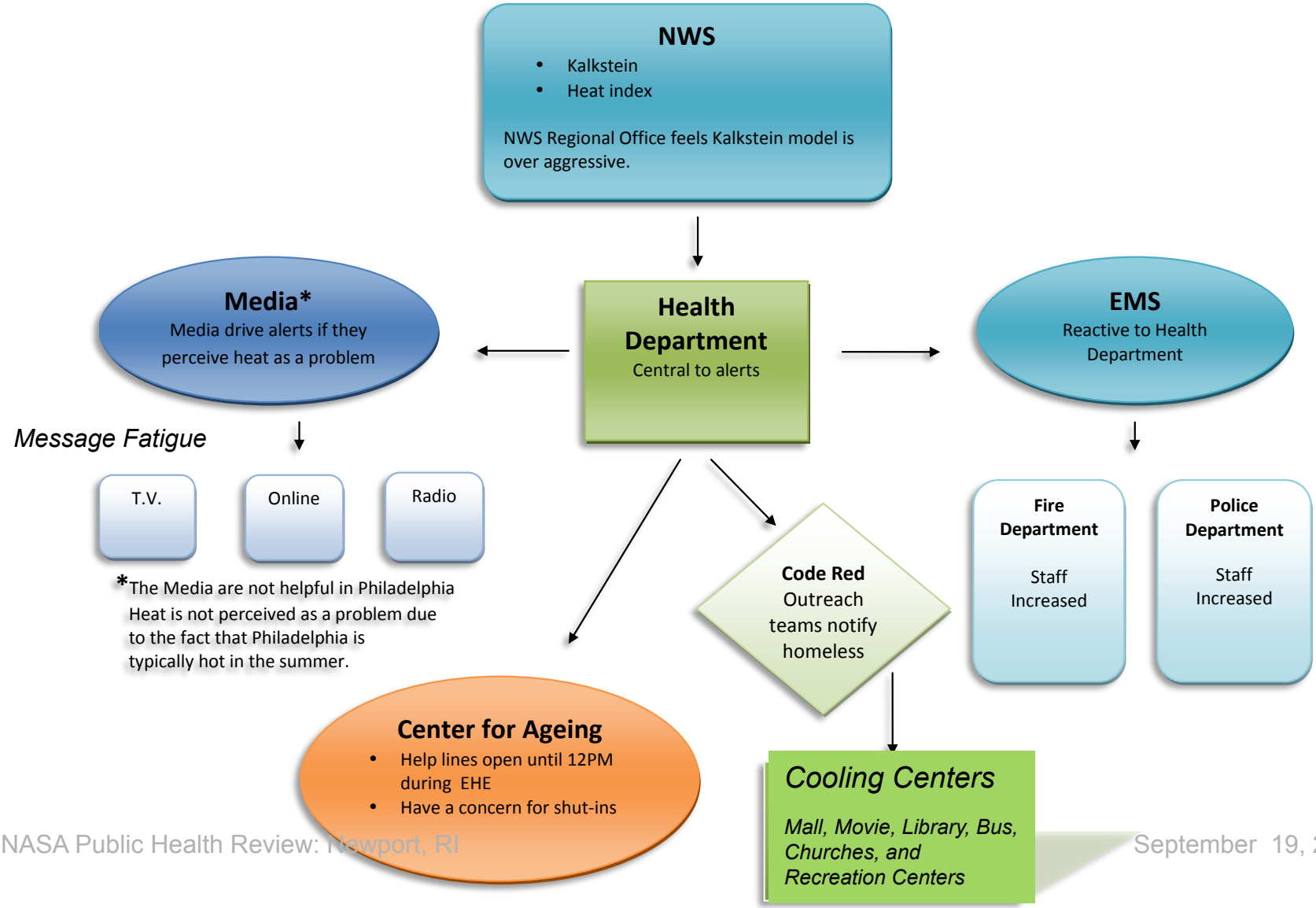
Issues with Census 2010 data

- Lack of continuity between the 1990, 2000, and 2010 census has caused multiple problems
- 2010 data that is useful for our project is categorized differently.
- Most indicators are in the American Community Survey; which is a survey.
- Different variables for a few of the vulnerability indicators
- We have had to validate many 2010 variables with past 2000 and 1990 variables to ensure consistency.
- Therefore the 2010 model is not the same as the 1990 and 2000 model in the variables used.

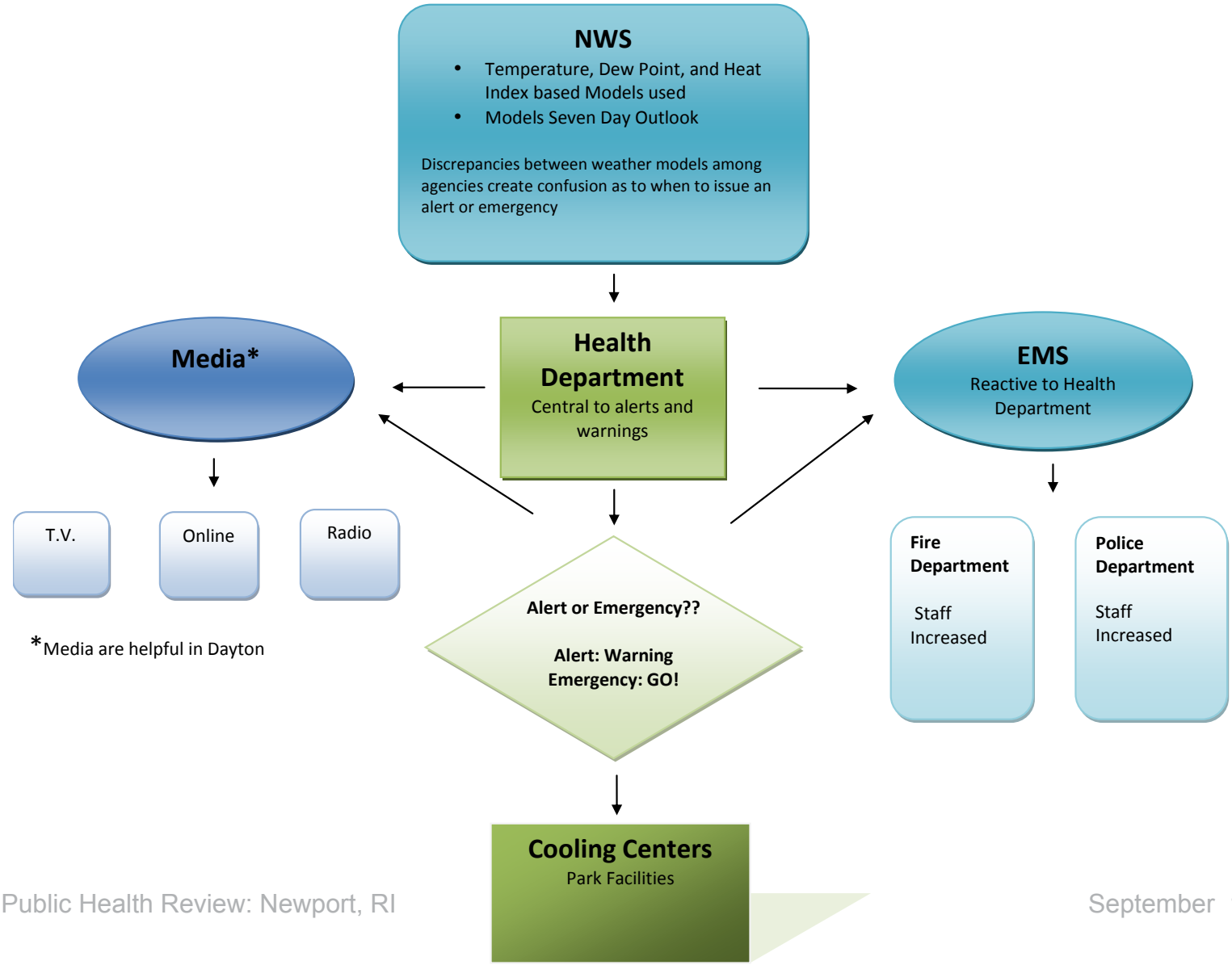
Community Outreach

- Series of focus groups for each city with appropriate organizations/personnel were conducted in person
  - Dayton
  - Phoenix
  - Philadelphia
- Other interest:
  - Indianapolis, Chicago, New York, Tampa Bay…

Philadelphia Response Flow Chart



Dayton Response Flow Chart



Community Outreach

- Dayton: 7 agencies / 18 participants
- Phoenix: 5 agencies / 15 participants
- Philadelphia: 5 agencies / 18 participants

  EMS, Police, Fire, NWS, Health…

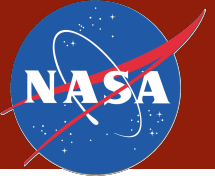
- Follow-up calls
  - ITEC Interns call Summer 2012
  - Soon to conduct conference calls with each agency.

Community Outreach Summer call

- 27/27 (**100%**) felt that community preparedness made a difference in the ability of emergency officials to respond after a disaster.
- 22/27 (**81.4%**) would not consider purchasing EHVI
  - 4/27 (**14.8%**) might consider buying it
  - 1/27 (**3.7%**) were not sure.
- 5/27 (**18.5%**) did not use any geographical information system
  - they do not need one.
- Only 3/27 (**11.1%**) currently had a heat wave vulnerability assessment system. Of these, only 1/27 (**3.7%**) would consider switching.
- Misunderstanding, calls thought we were selling a ESRI Arcmap replacement

Anticipated Uses in Emergency Response Capacities

- Improved identification of the “hottest” areas of individual cities and the surrounding municipalities.
- Time-Distance information from central emergency response locations to the most vulnerable areas within a city. *Some cities want this some don’t…*
- Intelligence-led location of cooling centers



INDIANA UNIVERSITY

System and Interface Development

WEB-BASED SPATIAL DECISION SUPPORT SYSTEM

Philadelphia | Extreme Heat Event Project - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Philadelphia | Extreme Heat Event Project

Extreme Heat Event Project

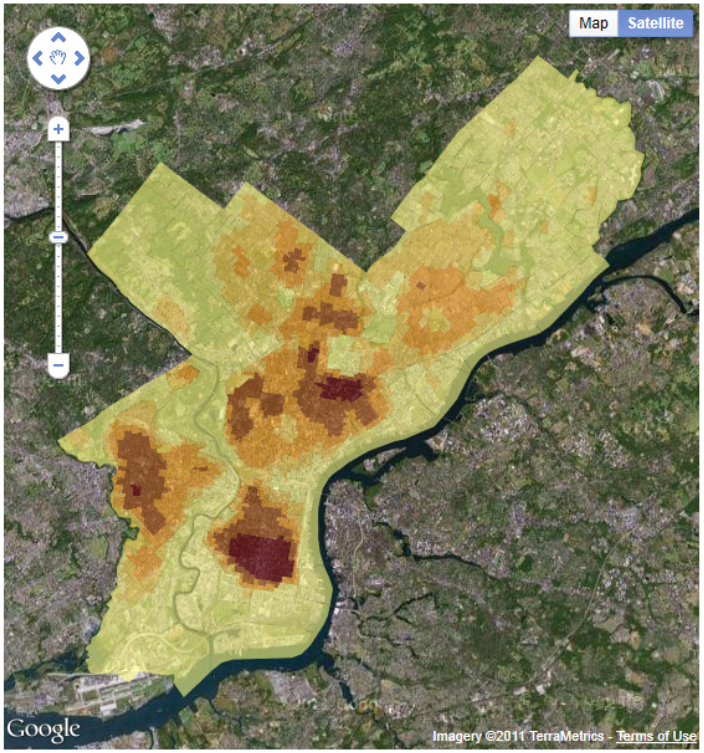
Home Dayton Philadelphia Phoenix

Navigation

- About Us

Philadelphia

Some more info about Philadelphia heat waves!



User login

Username *

Password *

- Request new password

Log in

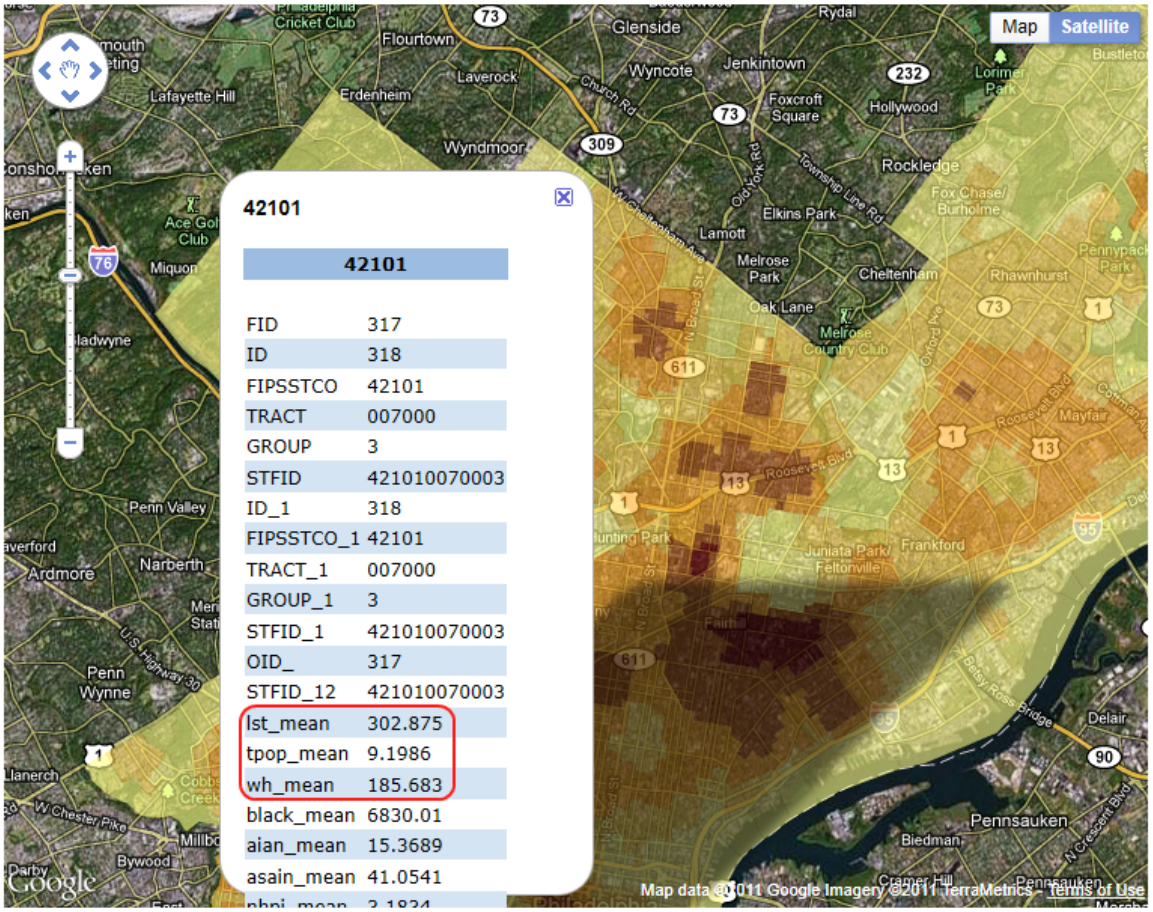
Powered by Drupal

Not even in Beta test phase

Improvements:

- *Daily temperature with 97th percentile*
- *Roads, Identifiers…*
- *LST map tab*
- *Neural Network tab*
- *Address locator*
- *Additional systems…*
  - *Cold, flood, burn…*

Some more info about Philadelphia heat waves!



Important Data Considerations

- Currently exploring downscaling MODIS to Landsat ETM+ and TM resolutions. Having varying levels of success…
- This will give us the ability to provide daily guidance to each city
- Re-calibrate on each “good” Landsat ETM+, Landsat TM, or ASTER as we can find it available or task the sensor?

Anticipated Improvement in Emergency Response Capacities

- Improved identification of locations that are particularly vulnerable
- Improved ability to mitigate the health-related impacts. Especially, when coupled with currently developing heat-health communication toolkits. http://www.bt.cdc.gov/disasters/extremeheat/
- Improved communication of events to especially vulnerable individuals/communities
- Disaster prevention funding documentation

Anticipated Activities for Coming Year

- Continue interaction with focus groups
- Implement the ensemble of models and begin full implementation in each city
- Automation of process
- Collect mortality/911 data for this past summer; further enhance interface for model re-runs

Anticipated Activities for Coming Year

- Continue work on MODIS downscaling for daily guidance in each city
- Explore new cities that would be very good test areas for spatial expansion of the system (Indianapolis, Chicago have already been identified, NYC, Oklahoma City are future possibilities)
- Explore expansion spatially to statewide system…

Anticipated Media Change

- Social Media
  - Information outlet
    - Warning ‘tweet’ or text
    - Information portal
    - ‘check-in’ at cooling centers
  - Connect groups
    - Share ideas
    - What works, what doesn’t
    - Learn from one another
    - ‘City Bus’
- Help us design the product

Publicity

- Multiple peer review publications
- 2 text book chapters
- Showcased on FOX and NBC affiliates in Indiana in summer 2010, 2011, and 2012.
- Live radio interviews
- Multiple newspaper articles
  - They searched us out
- We plan a more aggressive press release initiative with each of our cities (and potential users) before summer season which will highlight our system

- ARL
  - Tested in a real world application, prior models are being used by cities.
  - Next summer ‘up to date’ systems implemented in mitigation plans
- Budget
  - Completion of no cost extension
  - Plan to exhaust remaining funds

A Special Thanks to Our Collaborators

Indiana University:
Dr. Vijay Lulla, Ph.D.
Jeremy Webber, MS Cand.

CDC:
Dr. George Luber, Ph.D.
Natasha Prudent, MPH
Marilyn DeSirios, Ph.D.

NASA Marshall:
Dr. Bill Crosson, Ph.D.
Dr. Dale Quattrochi, Ph.D.
Dr. Mohamad Al-Hamdan, Ph.D.
Sue Estes, MS
Maury Estes, MS
Sarah Hemmings, MS

And all of you.